#2/Prior Art
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3/7/02

In the United States Patent and Trademark Office

Appn. Number: Not Available
Appn. Filed: Not Available
Applicant(s): SAYOOD et al.
Appn. Title: see below *
Examiner/GAU: Not Available /1324

Mailed: With Application
At:

Information Disclosure Statement

Commissioner of Patents and Trademarks
Washington, District of Columbia 20231

Sir:

Attached is a completed Form PTO-1449 and copies of the pertinent parts of the references cited thereon.

Following are comments on these references pursuant to Rule 98:

* SYSTEM AND METHOD FOR JOINT SOURCE-CHANNEL ENCODING, WITH SYMBOL DECODING AND ERROR CORRECTION

PATENTS

With an eye to the present invention a Key-word Search for relevant Patents which involve inner and outer coding, trellis coding, data compression, error detection, error correction, variable length coding, arithmetic coding, and data transmission over noisy channels, has provided:

Patent No. 5,200,962 to Kao et al. is disclosed as it describes data compression with error correction.

Patent No. 5,745,504 to Bang is disclosed as it describes bit error resilient variable length code transmission.

Patent No. 6,009,203 to Liu et al. is disclosed as it describes variable length coding.

Patent No. 5,233,629 to Paik et al. is disclosed as it concerns trellis coded quadrature amplitude modulation.

Patent No. 4,862,464 to Betts et al. is disclosed as it describes error detection in digital modems using trellis coding.

Patent No. 5,206,864 to McConnell is disclosed as it concerns optimization of error correction, inner and outer coding.

Patent No. 5,841,794 to Inoue et al. is disclosed as it describes error correction for digital data.

Patent No. 5,910,967 to Vanderaar is disclosed as it describes concatenated coding in which an inner code is configured to match the needs of an outer code.

Patent No. 5,870,405 to Hardwick et al. is disclosed as it describes digital communication over noisy channels.

Patent No. 5,517,511 to Hardwick et al. is disclosed as it describes transmission of digital data over noisy channels.

Patent No. 5,983,382 to Pauls is disclosed as it concerns outer coding.

Patents disclosed because they discuss Arithmetic coding are:

DG Patent No. 5,311,177 to Kimura et al.;
Patent No. 5,587,710 to Choo et al.;
Patent No. 5,418,863 to Ando;
Patent No. 4,295,125 to Langdon, Jr;
Patent No. 4,286,256 to Langdon, Jr. et al;
Patent No. 5,774,081 to Cheng et al.;
Patent No. 5,715,332 to Nakanishi;
Patent No. 5,710,826 to Osawa et al.;
Patent No. 5,317,428 to Osawa et al.

ARTICLES

"Error Recovery for Variable Length Codes", Maxted et al., IEEE Trans. on Information Theory, IT-31, p. 794-801, (Nov. 1985) examines the effect of errors on variable length codes.

"Error Recovery for Variable Length Codes", Monaco, IEEE Trans. on Information Theory, IT-33, p. 454-456, (May 1987) provides corrections and additions to the Maxted article.

Said work was later extended by:

"Simplified Expression for the Expected Error Span Recovery for Variable Length Codes", Soualhi et al., Intl. J. of Electronics, 75, p. 811-816, (Nov. 1989),

"Effects of a Binary Symetric Channel on the Synchronization Recovery of Variable length Codes", Rahman et al., Computer J., 32, p. 783-792, (Feb. 1994);

"Error States and Synchronization Recovery for Variable Length Codes", Takishima et al., IEEE Trans. on Communications, 42, p. 346-251;

"More on the Error Recovery for Variable Length Codes", Swaszek et al., IEEE Trans. on Information Theory, IT-41, p. 2064-2071, (Nov. 1995);

all of which focused mainly on the resynchronization ability of Huffman Codes.

"Implementation Issues in MAP Joint Source/Channel Coding", Sayood, Liu and Gibson, Proc. 22nd Annular Asilomar Conf. on Circuits, Systems, and Computers, p. 102-106, IEEE, (Nov. 1998), is one of the earliest works, in terms of joint source channel coding where the source and source coder characteristics are used to provide error protection. Assuming a Markov model for the source coder output they used packetization to prevent error propagation and the residual redundancy at the source coder output to provide error protection.

Other references have similar focus:

"Decoding Entropy-Coded Symbols Over Noisy Channels by MAP Sequency Estimation for Asynchronous HMMs", Park et al., Proc. Conference on Information Sciences and Systems, IEEE, (March 1999).

"Robust Transmissions of Variable-Length Encoded Sources", Mruad and Fuja, in Proc. IEEE Wireless and Networking Conf. 1999, (Sept. 1999); and

"Joint Source Channel Coding for Variable Length Codes", Sayood, Otu and Demir, IEEE Transactions on Communications, 48 p. 787-794, (May 2000);

describe designs which make use of the redundancy at the source coder output for error correction.

The problem of low bandwidth hostile channels can also be addressed using error silent source codes which incorporate the possibility of errors in the channel and provide mechanisms for error concealment. Work in the area includes

"Robust Image Compression Based on Self-Synchronizing Huffman Code and Inter-Subband Dependency", Yang, Proc. thirty-second Asilomar Conference on Signals, Systems and Computers, p. 986-972 (Nov. 1997), describes use the self- synchronizing property of suffix rich Huffman codes to limit error propagation, and correlation between subbands to provide

error correction/concealment.

In addition, there exist a number of concatenated schemes in which the source and channel coders are concatenated in the traditional manner with channel resources allocated between them based on the characteristics of the channel. If the channel is very noisy, more bits are allocated to the channel and fewer to source coding, and the situation is reversed when the channel conditions are more favorable. Examples of this approach include:

"Robust Image Compression for Time Varying Channels", Regunathan et al., Proc. Thirty-first Asilomar Conf. on Signals, Systems and Computers, p. 968-972, (Nov. 1997);

"Progressive Image Coding for Noisy Channels", by Sherwood et al., IEEE Signal Processing Lett., 4 p. 189-191, (July 1997).

Most of the schemes referenced above use Huffman coding or variants thereof as the variable length coding scheme, however, with the increasing popularity of arithmetic coding, there has developed interest in joint source channel coding schemes which use said arithmetic coding such as:

"Arithmetic Coding Algorithm with Embedded Channel Coding", ElMasry, Electronics Lett., 33 p. 1687-1688, (Sept. 1997), involves generation of parity bits which are embedded into arithmetic coding procedure for error correction.;

"Integrating Error Detection into Arithmetic Coding", Boyd et al., IEEE Transactions on Communications, 45(1), p. 1-3, (Jan. 1997), showed that by reserving probability space for a symbol which is not in the source alphabet the arithmetic code can be used for detecting errors.

Reserving probability space for a symbol that will never be generated means that less space remains for the source alphabet and this translates into a higher coding rate. Said overhead, however, is small considering the capability of error detection enabled, as described in:

"Image Transmission Using Arithmetic Coding Based on Continuous Error Detection", Kozintsev et al., Proc. of Data Compression Conf. p. 339-348, IEEE Computer Society Press, (1998), which describes two scenarios, (eg. Automatic Repeat Request (ARQ) based communications and serially concatenated coding schemes with an inner error correction code and an outer error detection code, which use error detecting capability of the arithmetic code with an error detection space.

Sincerely,

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